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REMARKS

Claim Rejections - 35 USC §102

Claims 1-4, 7-10, and 13-16 are rejected under 35 USC §102(a) as being anticipated by Zhao et al. (USPN 6,100,184, hereinafter "Zhao").

With regard to claims 1-4, Applicants have amended claim 1 to clarify that the term "channel" therein is a "channel opening". The error was inadvertent since those skilled in the art often interchange the two terms since a channel can mean both a groove for a conductor as well as a conductor that carries a current. The support for the amendment is based on the prior art method of formation of the channel and the channel opening combined with the disclosure of the present invention.

The Specification page 6, lines 12-16, describes the prior art:

"The damascene process is a photolithographic process which uses a mask and developing to define a first channel opening 125 in the first channel dielectric (oxide) layer 126. The first channel opening 125 was then filled with the thin barrier layer 121, the thin seed layer 122, and the first conductive material, such as copper, to form the first channel 101 using conventional metal deposition techniques..." [underlining and deletion for clarity]

The Specification page 7, lines 15-17, supports the relevant portion of the amendment with reference to the present invention:

"In production with the present invention as shown in FIGs. 3-5, said steps are the same through the first damascene process of filling the first channel opening with the thin adhesive layer 221, the thin seed layer 222, and the first conductive material."

It is respectfully submitted that the Applicants' claimed combination, as exemplified in amended and clarified claim 1, includes the limitation not disclosed in Zhao of:

"a second barrier layer disposed over said conductive layer in said channel opening, said second barrier layer of a metallic barrier material, whereby said conductive material is totally enclosed in metallic barrier material." (underlining added)

The above indicates that the second barrier layer is in the channel opening, which means the second barrier layer acts like a plug to prevent electromigration from the

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conductive layer. The formation of this structure is disclosed in Specification page 7, lines 20-28:

"The conductive material in the first channel 201 is then subject to an etch back.... Generally, the predetermined etch back will remove at least as much of the first channel 201 as required for the thickness of a conventional barrier layer to form the recessed first channel 201."

The semiconductor interconnect barrier layer 206 is then deposited...using the same methods as used for depositing the barrier layer 121. This process fills the etch back recess and subsequent CMP forms the self-aligned semiconductor interconnect barrier 208 which is automatically self-aligned with the recessed first channel 201."

Zhao discloses that the "etching or polishing step removes the excess metal material above the surface of the structure" and then the "encapsulation layer 34 is selectively formed above the exposed copper in order to fully encapsulate the copper" (Col. 10, lines 11-15). As is shown in FIG. 16 of Zhao, the resulting encapsulation layer 34 is not self-aligned and is located above the level of the channel defined in the ILD layer 18. Thus, Zhao discloses a cap over the Zhao channel, which would permit conductor material electromigration and/or diffusion.

In contrast, the second barrier layer in the Applicants' invention acts as a plug located inside the channel to plug, or prevent, conductor material electromigration and/or diffusion. In the Applicants' Specification, the conductive layer is referred to as the "recessed first channel 201" which has its surface "etched back or recessed to reduce its height by a 'predetermined' thickness" (Specification page 5, lines 27-29). Subsequently, the second barrier layer is deposited over the recessed first channel 201 and a CMP process removes excess barrier material so that the second barrier layer "fills the etch back recess" (Specification page 6, lines 25-26). Thus, the Applicants' second barrier layer is a self-aligned plug, filling the channel instead of resting on top. Because of this, the problem of diffusion at the interface between the first and second barrier layers that would be present in Zhao is solved in the Applicants' invention.

The dependent claim 2 depends from independent claim 1 and is believed to be allowable since it contains all the limitations set forth in the independent claim from which it depends and claims nonobvious combinations thereof including a first barrier layer of a metallic barrier material selected from a group of specified materials.

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The dependent claim 3 depends from independent claim 1 and is believed to be allowable since it contains all the limitations set forth in the independent claim from which it depends and claims nonobvious combinations thereof including a second barrier layer of a metallic barrier material selected from a group of specified materials.

The dependent claim 4 depends from independent claim 1 and is believed to be allowable since it contains all the limitations set forth in the independent claim from which it depends and claims nonobvious combinations thereof including a conductive material selected from a group of specified materials.

With regard to claims 7-10 and 13-16, the Examiner states that "the steps of providing, forming, removing, and depositing are deemed to be inherently taught by Zhao et al" based upon the structure shown in Zhao. As was explained with reference to claim 1 above, Zhao's structure teaches away from the Applicants' invention, as the second barrier layer in Zhao is above the channel instead of in the channel as disclosed in the Applicants' invention. It follows therefore, that the steps of providing, forming, removing, and depositing the structure in the Applicants' invention is patentably distinct from Zhao.

In particular, the Applicants' claimed combination, as exemplified in claim 7, includes the limitations not disclosed in Zhao of:

"removing a portion of said conductive layer inside said opening; and forming a second barrier layer over said conductive layer in said opening..." (underlining added)

From the above, there can be seen to be two limitations not disclosed in Zhao: a first limitation with the additional step of "removing a portion of said conductive layer inside said opening", and a second limitation of deposition into the opening.

Zhao does not teach or suggest the first limitation of removing conductive layer inside the opening. As shown in Zhao FIG. 16, there is no portion of the conductive layer that is removed from inside the opening. Further, there is no disclosure in the specification of Zhao of any process that removes any portion of the conductive layer from inside the opening.

Zhao specifically teaches away from the second limitation of deposition into the opening. Zhao's specification teaches using techniques "to selectively deposit" the second barrier layer "atop the exposed metal region" (column 10, lines 19-21). The deposition process atop the exposed metal region requires accurate location and alignment.

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In marked contrast, the Applicants' patent uses, as the title, a "Self-Aligned Semiconductor Interconnect Barrier Layer...", suggests, a self-aligned deposition process which deposits the second barrier layer into the opening rather than atop it. The essence of the barrier being self-aligned requires that a portion of the conductive layer from inside the opening be removed, and that the formation of the second barrier layer be inside the opening as specified in the above claim.

Thus, the steps of providing, forming, removing, and depositing of the Applicants' claims 7-10, 13-16 are not believed to be inherent in Zhao.

With particular regard to independent claims 7 and 13, it is respectfully submitted that these claims have not been amended because they do not require the clarification made to claim 1 in that they contain the limitations as to the opening and the barrier layer being in the opening which is not disclosed, taught, or suggested in Zhao. This is exemplified in claim 7:

"forming an opening in said dielectric layer;

...

removing a portion of said conductive layer inside said opening; and
forming a second barrier layer over said conductive layer in said
opening..."[deletions for clarity]

The dependent claims 8 and 14 respectively depend from independent claims 7 and 13, and are believed to be allowable since they contain all the limitations set forth in the independent claim from which they depend and claim unobvious combinations thereof including a first barrier layer of a metallic barrier material selected from a group of specified materials.

The dependent claims 9 and 15 respectively depend from independent claims 7 and 13, and are believed to be allowable since they contain all the limitations set forth in the independent claim from which they depend and claim unobvious combinations thereof including a second barrier layer of a metallic barrier material selected from a group of specified materials.

The dependent claims 10 and 16 respectively depend from independent claims 7 and 13, and are believed to be allowable since they contain all the limitations set forth in the independent claim from which they depend and claim unobvious combinations thereof including a conductive material selected from a group of specified materials.

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Claim Rejections - 35 USC §103

Claims 5, 6, 11, 12, 17, and 18 are rejected under 35 USC §103(a) as being unpatentable over Zhao in view of Dubin et al. (USPN 5,695,810, hereinafter "Dubin").

The dependent claims 5, 11, and 17 respectively depend from independent claims 1, 7, and 13, and are believed to be allowable since they contain all the limitations set forth in the independent claim from which they depend and claim unobvious combinations thereof including the first and second barrier layers are of the same metallic barrier material.

More specifically, Applicants respectfully submit that absent a teaching suggesting that the material of the first and second barrier layers be the same, such a conclusion is not obvious. Absent some teaching, this conclusion then is an application of an "obvious to try" standard, which is an inappropriate standard of obviousness as indicated in *In re Lindell*, 385 F.2d 435, 155 USPQ 521 (C.C.P.A. 1967), which criticized this test.

"These are, perhaps, the obvious areas to try. But resulting inventions are not necessarily obvious. Serendipity is not a prerequisite to patentability. Our view is that "obvious to try" is not a sufficiently discriminatory test."

The dependent claims 6, 12, and 18 respectively depend from independent claims 1, 7, and 13, and are believed to be allowable since they contain all the limitations set forth in the independent claim from which they depend and claim unobvious combinations thereof including the first and second barrier layers having substantially the same thickness.

In particular, the Applicants respectfully submit that it would not have been obvious to modify Zhao in view of Dubin. The Examiner stated in the Office Action page 3, next to last paragraph, that:

"Zhao et al fails to express a particular thickness of the second barrier layer but refers to a particular application for deposition technique which is related to the Dubin et al patent which teaches forming said layers in the range of thickness as those discussed by Zhao et al with regard to the first barrier layer."

Zhao Col. 10, lines 26-30, refers to Dubin, and discloses that the first barrier layer in Zhao is of approximate thickness of 100-1000 angstroms (Col. 8, lines 30-35), but Dubin does not teach forming a second barrier layer in the range of thickness as those discussed by Zhao for the first barrier layer. Dubin only discloses the composition and method of depositing a barrier layer and does not disclose the thickness to which a barrier layer should

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be formed. Therefore, both Zhao and Dubin fail to disclose the thickness of the second barrier layer.

Further, the first barrier layer in Zhao is "conformally deposited" (Col. 8, lines 19-21 and 36-38), while the second barrier layer in Zhao is selectively deposited (Col. 10, lines 18-20). Because the two barrier layers are deposited with different methods, in different places, and with different inherent problems, the Applicants respectfully submit that it would not be obvious to modify Zhao in view of Dubin to render the Applicants' invention obvious.

The other references cited by the Examiner showing the prior art have been considered and are not believed to disclose, teach, or suggest, either singularly or in combination, Applicants' invention as claimed.

New Claims

During a telephone conversation with the Examiner on or about December 4, 2002, to receive clarification of the Office Action, the Examiner commented that the terminology of the specification was not used in the claims. Device claims 19 and 20 have been added, which include the elements "recessed channel" and "self-aligned semiconductor interconnect barrier" as used in the specification, respectively beginning on page 5, line 20, with regard to FIG. 3 and on page 3, line 30, and page 4, lines 4 and 5, in the Disclosure of the Invention.

Conclusion

In view of the above, it is submitted that the claims are in condition for allowance and reconsideration of the rejections is respectfully requested. Allowance of claims 1-20 at an early date is solicited.

During the telephone conversation, the Examiner indicated the problem and suggested additional search would be required upon amendment of the claims. The Applicants appreciate the Examiner's hard work and diligence in doing a thorough job in searching this application. It is respectfully submitted that no additional search is required, which will delay issuance of this application, because of the simplicity of the clarification and the lack of amendment to independent claims 7 and 13. MPEP § 904.02 strongly encourages the Examiner to perform one thorough search instead of many less-than-thorough searches and it is submitted that the Examiner has performed a thorough search.

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To the extent necessary, a petition for an extension of time under 37 C.F.R. 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including any extension of time fees, to Deposit Account No. 01-0365 and please credit any excess fees to such deposit account.

Respectfully submitted,



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NOTE: The "VERSION WITH MARKINGS TO SHOW CHANGES MADE" begins on the following page.

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

- Please amend claim 1 by inserting the underlined text and deleting strike-through text as follows:

1. (Amended) A semiconductor device, comprising:
a semiconductor with a dielectric layer formed thereon, wherein said dielectric layer overlays a region on said semiconductor and has a channel opening provided therein;
a first barrier layer disposed in said dielectric layer lining said channel opening, said first barrier layer of a metallic barrier material;
a conductive material disposed in said first barrier layer in said channel opening; and
a second barrier layer disposed over said conductive layer in said channel opening,
said second barrier layer of a metallic barrier material, whereby said conductive material is totally enclosed in metallic barrier material.

- Please add new claims 19 and 20 as follows:

19. (New) A semiconductor device, comprising:
a semiconductor;
a dielectric layer formed on the semiconductor, said dielectric layer having a channel opening provided therein;
a recessed channel in said channel opening including:
a first barrier layer disposed in said channel opening, said first barrier layer of a metallic barrier material; and
a conductive material disposed in said first barrier layer; and
a self-aligned semiconductor interconnect barrier disposed over said recessed channel in said channel opening.

20. (New) The semiconductor device as claimed in claim 19 wherein said first barrier layer and said self-aligned semiconductor interconnect barrier totally enclose the conductive material.